Thesis/
Reports
Daniel,
T. C.

SCENIC BEAUTY PREDICTION MODEL: APACHE-SITGREAVES NATIONAL FOREST FINAL REPORT

Alaska monthly
Climatological Data

'75 '76

SCENIC BEAUTY PREDICTION MODEL:

APACHE-SITGREAVES NATIONAL FOREST

FINAL REPORT

Cooperative Agreement No. 16-743-CA

Supplemental Agreement No. X2

The University of Arizona and the Rocky

Mountain Forest and Range Experiment

Station, Forest Service, USDA

TERRY C. DANIEL

Principle Investigator

January 1980

National FS Library
USDA Forest Service

NOV 25 2008

240 W Prospect Rd
Fort Collins CO 80526

SCENIC BEAUTY PREDICTION MODEL: APACHE-SITGREAVES NATIONAL FOREST

Herbert Schroeder and Terry C. Daniel

University of Arizona

The Scenic Beauty Estimation (SBE) method (Daniel and Boster, 1976) was developed to provide forest managers with quantitative assessments of the esthetic quality of natural landscapes. The procedure has proven reliable and valid and has been used successfully to measure differences in the public's perception of the scenic beauty of different forest areas. The SBE method has also been used to measure the scenic effects of different forest management treatments.

Precise assessment of existing scenic values is important. However, if the SBE method is to be used to evaluate alternative management proposals before they are implemented, the scenic impacts of the proposed management actions must be predicted in advance. Expected scenic impacts can then be evaluated and compared with anticipated impacts on other forest resources and products (such as wildlife, timber, and water).

One way of predicting scenic impacts of proposed management plans is with statistically derived scenic beauty prediction equations. Arthur (1977) had foresters estimate forest characteristics by inspecting color slide representations of forest areas. Estimates were made of the number of trees per acre in several size classes, the amount of downed wood per acre, and several other factors. These physical feature values were combined into a multiple regression equation that accurately predicted public observers' judgments of the scenic beauty of the forest areas represented by the slides.

Schroeder and Daniel (1978) extended these efforts to develop a valid and useful model for predicting perceived scenic beauty of forest landscapes in the Coconino National Forest. Forest features were determined by direct

in-the-field inventories of overstory, understory, ground cover, and downed wood characteristics of the forest sites. Color slides, coordinated with these inventories, were shown to panels of observers to obtain SBE values for each site. The relationship between the physical forest features and the SBE values was then determined and served as the basis for scenic beauty prediction models. A simple model was developed for ponderosa pine landscapes. The model accounted for more than fifty percent of the variance in scenic beauty judgments, using measures of ground cover, downed wood, and numbers of trees. Also, a model was developed for forest areas with more diverse species compositions.

The present study extends this work to other forest areas in Arizona. Using a similar inventory procedure, scenic beauty models for landscapes in the Apache-Sitgreaves National Forest were derived. These models can be compared with the models developed for the Coconino National Forest to determine the feasibility of extending scenic beauty prediction models to forests other than those for which they were originally developed. This research can also help to identify problems that may occur when such extensions are attempted.

Method

The inventory procedure of Schroeder and Daniel (1978) was applied to plots in the Apache-Sitgreaves National Forest. First a location for the center of each plot was selected and marked with a wooden stake. A random compass heading was used to determine the orientation of the diagonals of a square sample plot. Four photographs were taken from the center of the plot, each oriented along one of the plot diagonals. Four additional photographs were taken one from each of the plot corners oriented toward the center point.

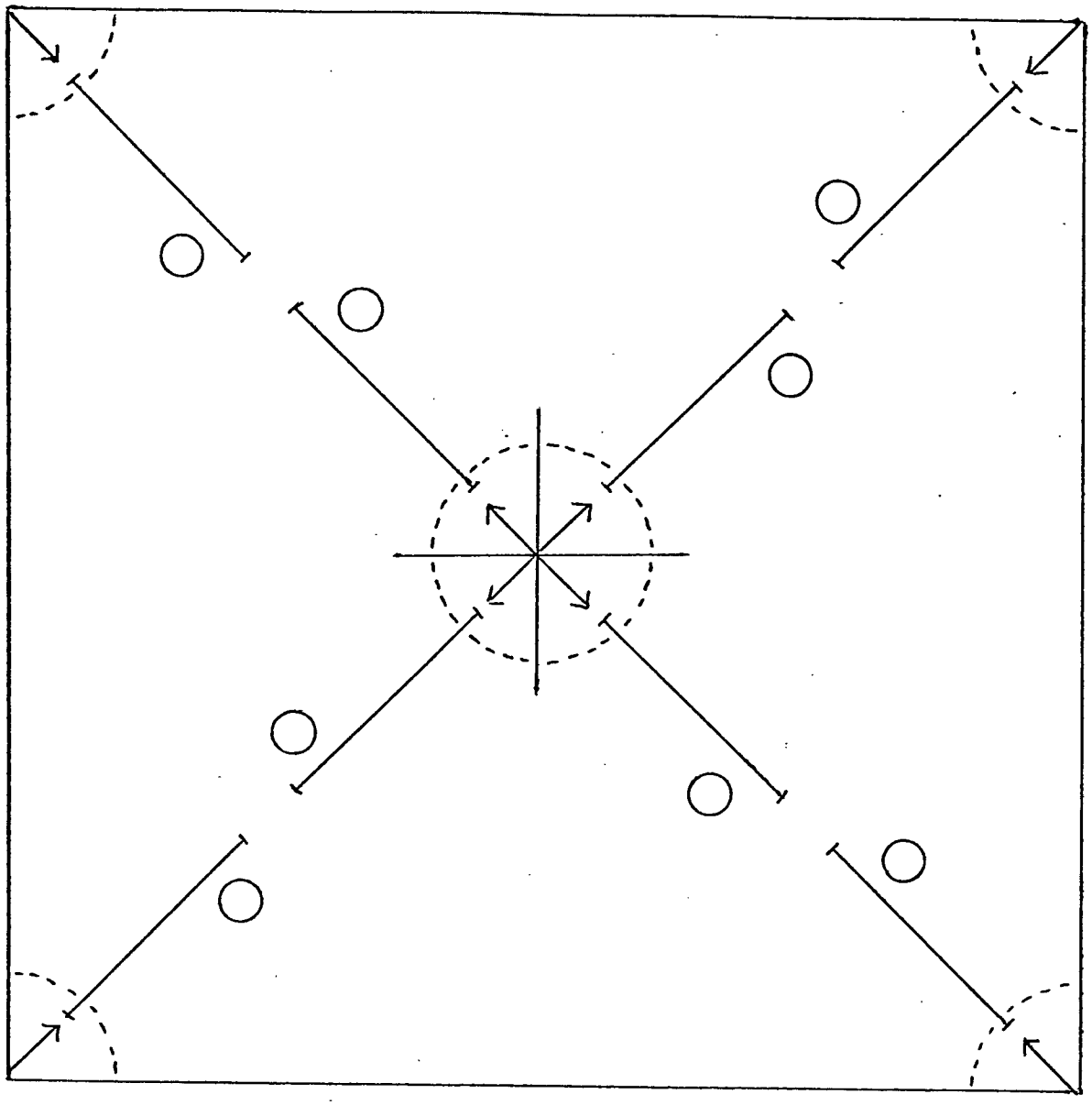
After the photographs were taken, timber, downed wood and vegetative ground cover were inventoried. Eight measurements of each physical variable were made on each plot, with each measurement corresponding to one of the eight photographs. The sampling scheme is illustrated in Figure 1.

Forest Inventory--Trees greater than five inches in diameter were inventoried using a prism with a basal area factor of ten. A complete 360 degree sample was taken around the center point. This sample subdivided into four 90 degree quadrants corresponding to the directions in which the photos were taken. At each corner point another sample was taken covering the 90 degree quadrant directed toward the interior of the plot. Seedlings and saplings were counted in 300-foot-long strips lying along the diagonals of the plot. The strips were five feet wide for seedlings, and ten feet wide for saplings.

Downed wood was inventoried using the method of Brown (1974). Two fifty-foot sample transects were placed on each line joining the center to a corner of the plot. The numbers of pieces of downed wood intersecting the line were tallied according to size. The species composition of the downed wood and a judgment about whether it was predominately natural or man-caused (slash) were also recorded.

Vegetative ground cover (range) was inventoried by placing one small circular plot, 9.6 square feet in area, next to each of the eight downed wood transects. The wet weight (in grams) of each species occuring within the circular plot was estimated. From the eight range plots, one was randomly selected and all of the plants in that plot were clipped. These were later dried and weighed. The dry weights were used to calculate a correction factor for converting field estimates of wet weight into estimates of dry weight.

Figure 1. Schematic of Sampling Procedure. Each plot was one acre in size, and plot orientation was randomly determined for each plot.



Key:

photograph ←

10 BAF timber sample

50' downed wood transect

range plot ○

Seventy-five forest plots were inventoried during the summer of 1978. There was an effort to achieve a "random sample" of forest sites. Sample plots were selected with aid of local Forest and District staffs. An effort was made to include instances of all important types of over story/under story conditions found in the ponderosa pine zone on the Apache-Sitgreaves National Forest. Some mixed conifer plots were also included.

The eight color slides from each plot were shown to groups of introductory psychology students, who rated the scenic beauty of the areas represented using a ten-point scale. Slides from all plots were randomly intermingled in sets of approximately 100. A total of approximately 30 observers provided judgments for each slide. Except for a "baseline" set which was judged by every observer group, a different set of sample slides was shown to each group of observers. Thus, a total of 180 observers in six groups provided judgments for the 600 slides. Slide ratings were analyzed by the method of Daniel and Boster (1976) to derive an independent Scenic Beauty Estimate for each forest area represented.

Results

The eight estimates of physical characteristics, and the eight SBE's for each plot were averaged together, resulting in a single estimate of each variable for each of the 75 plots. The plots served as cases in a multiple linear regression analysis. Plots were classified according to the percent of trees (excluding seedlings and saplings) which were ponderosa pine. Models were then developed for forests which are predominately ponderosa pine, as well as for forests with a more diverse mixture of species.

For these models, inventoried forest features are combined into an equation that predicts perceived scenic beauty. The form of these equations is: $SBE = a + B_1 X_1 + B_2 X_2 + B_3 X_3 \ldots$

Where:

a is a constant (intercept).
B_1 is the unstandardized coefficient for variable 1.
X_1 is the measured value of variable X_1 (e.g., number of large trees).

Stepwise regression analysis was performed separately for cases with 80 percent or more ponderosa pine (37 cases), and for all cases regardless of species composition (75 cases). Tables 1 and 2 show the resulting regression models for predicting scenic beauty. The multiple correlation coefficients (R) are very high, accounting for 85 percent of the variance in scenic beauty judgments when restricted to predominately ponderosa pine plots, and 96 percent of the variance for plots with all species.

The tables only show the first few variables to enter the equation, but it can be seen that the multiple correlation coefficient (R) increases very rapidly on the first few steps. In other words, the full set of predictors is not really necessary, since a few well-chosen variables can predict scenic beauty quite well.

The coefficients of the regressions equation (B's) depend on the units of measurement of the predictors and therefore do not directly reflect the importance of individual predictors in the equation. The Beta coefficients (Standardized regression coefficients, B) are based upon the standard deviations of the predictors' distributions, and therefore are a more pure measure of the importance of each variable for predicting scenic beauty. A high beta for a variable indicates that the prediction equation is relatively sensitive to changes in that variable. The tables also present an alternative measure of the sensitivity of the equation to changes in the predictors. The numbers in the column labeled "sensitivity" tell how much the predicted SBE will change as a result of a 10 percent increase in the predictor, evaluated at the mean value of the predictor.

Table 1. Apache-Sitgreaves detailed regression model for plots with 80 percent or greater Ponderosa Pine. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Downed wood: sound 3-12": cu.ft./acre	309.05	249.28	.0097	.0647	.525	.300
2	Grass: lbs/acre	54.68	38.73	.9819	1.014	.626	5.37
3	Ponderosa Pine: 24-28" DBH: Trees/acre	2.11	2.46	12.45	.8408	.681	2.63
4	Aspen: 20-24" DBH: Trees/acre	.098	.436	32.03	.3916	.719	.314
5	Forbs: lbs/acre	40.25	28.78	-.7943	-.6095	.750	-3.20
6	Ponderosa Pine: seedlings: Trees/acre	371.95	806.27	.0162	.3639	.776	.603
7	Oak: Saplings: Trees/acre	14.74	56.08	.3511	.5519	.802	.518
8	Ponderosa Pine: 16-20" DBH: Trees/acre	12.19	11.86	1.033	.3414	.821	1.26
9	Ponderosa Pine: 9-12" DBH: Trees/acre	22.56	28.89	.4154	.3281	.841	.937
10	Oak: 16-20" DBH: Trees/acre	.222	.799	-16.78	-.3752	.860	-.373
	Scenic Beauty	35.06	37.51				

Number of plots: 37
Number of predictors: 22
Final R: .92

$F(22, 14) = 3.62$
$p < .01$

Standard Error: 27.63

Table 2. Apache-Sitgreaves detailed regression model for all plots. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Ponderosa Pine: 28+" DBH: Trees/acre	1.18	2.06	5.395	.2776	.409	.637
2	Forbs: lbs/acre	57.84	54.28	-.8399	-1.141	.522	-4.86
3	Aspen: Seedlings: Trees/acre	240.16	480.67	.1131	1.362	.595	2.72
4	Spruce: 9-12" DBH: Trees/acre	3.23	10.88	-8.499	-2.314	.629	-2.75
5	Ponderosa Pine: 20-24" DBH: Trees/acre	8.14	10.40	.9581	.2495	.658	.780
6	Juniper: 5-9" DBH: Trees/acre	.952	4.69	8.068	.9481	.675	.768
7	Downed wood: sound 3-12": cu. ft./acre	433.79	480.79	-.0493	-.5937	.690	-2.14
8	Fir: Saplings: Trees/acre	42.75	112.50	-.7807	-2.199	.731	-3.34
9	Grass: lbs/acre	50.68	38.55	1.020	.9847	.755	5.17
10	Downed wood: 0-¼": cu. ft./acre	13.30	11.45	-1.244	-.3567	.775	-1.66
	Scenic Beauty	42.23	39.94				

Number of plots: 75
Number of predictors: 64
Final R: .98

F (64, 10) = 4.18
$p < .01$

Standard Error: 23.79

These detailed models are successful in terms of the amount of variance accounted for, but they have some serious problems. The large number of different variables used results in an unwieldy model requiring large amounts of detailed data. Also, many of the individual predictors are correlated among themselves. For example, numbers of trees in adjacent size classes are typically positively correlated. This multicolinearity may cause estimates of the regression coefficients to be unreliable, and makes it difficult to isolate the scenic effects of individual variables.

Both of these problems may be reduced by combining or grouping some of the separate predictors used in the detailed models into a smaller number of less detailed predictors. For example, trees per acre could be represented by three size classes (5-11.9" DBH, 12-20" DBH, and 20" +) instead of the seven size classes used in the field inventory. This reduces the amount of detailed data which must be entered into the model, and can also reduce the intercorrelations between predictors. The result is a model with a smaller multiple R, but which is easier to apply, and provides better estimates of the regression coefficients of each of the predictors.

A simplified model for application to forest landscapes with 80 percent or more ponderosa pine is shown in Table 3. The predictor variables were formed by grouping the detailed inventory variables in a way which produced the highest possible multiple R with a limited number of variables. The multiple R is still reasonably high, accounting for 58 percent of the variance in SBE's. The coefficients of the predictors are intuitively reasonable and in general accordance with past research, except for that of forbs. Past research, has shown forbs to be a consistently positive scenic influence, but the current model gives it a negative coefficient. Possible reasons for this will be discussed below. Consistent with past research, downed wood

Table 3. Apache-Sitgreaves Regression model for plots with 80 percent or greater Ponderosa Pine.

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Downed wood: 0-3": cu. ft./acre	262.99	161.07	-.128	-.550	.438	-3.37
2	Grass: lbs/acre	54.68	38.73	.976	1.01	.575	5.34
3	Forbs: lbs/acre	40.25	28.78	-1.08	-.826	.622	-4.35
4	Aspen: all sizes: Trees/acre	97.57	386.91	.037	.385	.673	.36
5	Oak: all sizes, excluding Saplings: Trees/acre	16.90	58.94	.208	.328	.705	.35
6	Downed wood: rotten > 3": cu. ft./acre	337.98	395.42	-.030	-.314	.729	-1.01
7	Ponderosa Pine: all sizes: Trees/acre	665.97	1085.79	.0085	.246	.754	.57
8	Shrubs: lbs/acre	6.26	12.30	.362	.119	.758	.23
9	Downed wood: sound > 3": cu. ft./acre	438.71	413.68	-.0062	-.069	.759	-.27
10	Oak: Seedlings: Trees/acre	217.57	477.95	-.0026	-.033	.759	-.06
	Scenic Beauty	35.06	37.51				

Number of plots: 37
Number of predictors: 10
Final R: .759

$F(10, 26) = 3.54$
$p < .01$

Standard Error: 28.72

has a negative scenic effect, aspen has a positive effect, and grass and shrubs also are positive.

A similar model was developed for all 75 plots (not restricted by species composition). In this model, shown in Table 4, non-ponderosa pine species (except juniper) are generally attractive, as is any kind of ground cover. The largest negative influence is sound downed wood between 3" and 12" in diameter.

For comparison, regression models for the original Coconino Inventory are shown in Tables 5 and 6. Variables have been defined differently in the Apache-Sitgreaves models than in the Coconino models, but the general nature of the models is similar. Ground cover is usually a positive scenic influence, while downed wood is generally negative. Different tree species vary in their effects, with species such as aspen and fir being consistently positive. Mature ponderosa pine also typically has a positive scenic effect.

Given the general agreement between the models for the Coconino National Forest and the Apache-Sitgreaves National Forest, the logical next step is to try to construct a single model applicable to both forests. This was attempted by combining the data for the Apache-Sitgreaves plots with the data from the original 94 Coconino Inventory plots, and using regression analysis to derive a model based on data from both forests. As before, the detailed inventory variables were grouped into less detailed predictors to reduce the problem of multicolinearity. Models for predominately ponderosa pine landscapes and for landscapes with all species are shown in Tables 7 and 8. The signs of the coefficients are for the most part intuitively reasonable, but the multiple R's are disappointingly low. As shown in Table 9, the R's for the combined models are considerably lower than for either the Coconino or the Apache-Sitgreaves models separately.

Table 4. Apache-Sitgreaves Regression Model for all plots. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Forbs: lbs/acre	57.85	54.28	.3098	.421	.406	1.79
2	Aspen: Seedlings and Saplings: Trees/acre	261.31	514.33	.0200	.258	.524	.52
3	Spruce: > 9" DBH: Trees/acre	6.96	23.11	.3640	.211	.564	.25
4	Downed wood: sound 3-12": cu. ft./acre	433.79	480.79	-.0554	-.667	.629	-2.40
5	Juniper: > 5" DBH: Trees/acre	3.04	11.41	-.4939	-.141	.661	-.15
6	Downed wood: rotten 3-12": cu. ft./acre	268.99	262.75	.0100	.066	.688	.27
7	Spruce: Saplings and 5-9" DBH: Trees/acre	17.27	48.92	.1132	.139	.704	.20
8	Ponderosa Pine: > 9" DBH Trees/acre	41.01	39.20	.3084	.303	.717	1.26
9	Grass and Shrubs: lbs/acre	61.20	51.37	.2334	.300	.734	1.43
10	Fir: Saplings and 5-9" DBH: Trees/acre	56.33	142.93	.1049	.375	.760	.59
	Scenic Beauty	42.23	39.94				

Number of plots: 75
Number of predictors: 24
Final R: .793

$F(24, 50) = 3.54$
$p < .001$

Standard Error: 29.57

Table 5. Coconine Inventory Regression Model for plots with greater than 90 percent ponderosa pine.

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Forbs: lbs/acre	32.44	58.04	.235	.483	.591	.76
2	Slash: cu.ft./acre	479.85	478.49	-.0137	-.231	.685	-.66
3	Ponderosa Pine: 5-16" DBH: Trees/acre	92.24	123.24	-.0691	-.301	.721	-.64
4	Shrubs: lbs/acre	5.15	14.78	.665	.348	.787	.34
5	Ponderosa Pine: > 16" DBH: Trees/acre	14.79	12.35	.388	.170	.796	.57
6	Grass: lbs/acre	71.53	143.88	.0278	.141	.802	.20
7	Ponderosa Pine: Seedlings and Saplings: Trees/acre	1538.68	2039.17	-.00083	-.060	.804	-.13
	Scenic Beauty	5.17	28.29				

Number of plots: 36
Number of predictors: 7
Final R: .804

$F(7, 28) = 7.30$
$p < .001$

Standard Error: 18.82

Table 6. Coconino Inventory Regression Model for all plots. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Forbs: lbs/acre	87.88	151.30	.0789	.346	.573	.69
2	Aspen: Trees/acre	226.93	1187.17	.0066	.227	.612	1.50
3	Ponderosa Pine: 16" DBH: Trees/acre	13.14	12.47	.682	.246	.649	.90
4	Grass: lbs/acre	67.33	103.65	.0873	.262	.681	.59
5	Juniper: Trees/acre	111.81	444.59	.0106	.137	.709	.12
6	Fir: Trees/acre	138.99	663.00	.0127	.244	.729	.18
7	Slash: cu. ft./acre	490.66	643.38	-.0127	-.237	.754	-.62
8	Oak: Trees/acre	994.04	1605.63	.00316	.147	.769	.31
9	Ponderosa Pine: 5-16" DBH: Trees/acre	98.98	109.55	-.0306	-.097	.775	-.30
10	Shrubs: lbs/acre	37.03	100.72	.0263	.077	.778	.10
	Scenic Beauty	21.50	34.56				

Number of plots: 94
Number of predictors: 13
Final R: .782

$F(13, 80) = 9.70$
$p < .001$

Standard Error: 23.21

Table 7. Combined Apache-Sitgreaves and Coconino Model for plots with greater than 80 percent ponderosa pine. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Forbs: lbs/acre	47.43	69.29	.0847	.165	.360	.40
2	Downed wood: 0-1": cu. ft./acre	84.42	49.68	-.0866	-.121	.429	-.73
3	Ponderosa Pine: > 9" DBH: Trees/acre	57.48	39.50	.243	.271	.467	1.40
4	Ponderosa Pine: 5-9" DBH: Trees/acre	78.38	97.30	-.0862	-.236	.511	-.68
5	Grass: lbs/acre	61.32	96.36	.102	.278	.541	.63
6	Aspen: all sizes	58.92	332.22	.0132	.123	.556	.08
7	Downed wood: 1-3": cu. ft./acre	141.13	104.63	-.0541	-.159	.564	-.76
8	Downed wood: sound > 12" cu. ft./acre	67.36	169.11	.0270	.128	.573	.18
9	Downed wood: rotten 3-12": cu. ft./acre	227.30	203.68	-.0109	-.062	.576	-.25
10	Oak: all sizes: Trees/acre	556.74	1064.64	.0024	.072	.577	.13
	Scenic Beauty	20.13	35.52				

Number of plots: 102
Number of predictors: 13
Final R: .579

$F(13, 88) = 3.41$
$p < .001$

Standard Error: 31.03

Table 8. Combined Apache-Sitgreaves and Coconino Model for all plots. (Only first ten predictors are shown).

Step	Variable	Mean	S.D.	B	Beta	R	Sensitivity
1	Forbs: lbs/acre	74.55	119.14	.0967	.301	.414	.72
2	Aspen: all sizes Trees/acre	251.80	953.55	.0093	.232	.475	.23
3	Ponderosa Pine: > 16" DBH: Trees/acre	14.83	14.39	.7208	.270	.531	1.07
4	Spruce: all sizes Trees/acre	25.10	112.46	.0887	.260	.590	.22
5	Grass: lbs/acre	59.94	81.67	.0822	.175	.609	.49
6	Fir: all sizes Trees/acre	161.23	574.14	.0093	.140	.624	.15
7	Downed wood: 0-3": cu. ft./acre	246.83	172.97	-.0259	-.117	.631	-.64
8	Downed wood: sound > 12": cu. ft./acre	117.31	311.79	.0154	.125	.639	.18
9	Ponderosa Pine: 5-9" DBH: Trees/acre	55.31	83.10	-.0405	-.088	.645	-.22
10	Pinyon Pine: all sizes Trees/acre	20.61	113.98	.0324	.096	.648	.07
	Scenic Beauty	30.70	38.35				

Number of plots: 169
Number of predictors: 17
Final R: .656

F (17, 151) = 6.72
$p < .001$

Standard Error: 30.52

Table 9. Multiple Correlation coefficients (R's) for scenic beauty prediction models.

	Apache-Sitgreaves	Apache-Sitgreaves and Coconino	Coconino
Ponderosa Pine plots	.76	.58	.80
All plots	.79	.66	.78

Discussion

The multiple R's for the Apache-Sitgreaves models reported here indicate that the model building procedure was as effective for this forest as it was for the Coconino. The major discrepancy between the models for the two forests is the effect of forbs in the ponderosa pine model. The negative effect of forbs in the Apache-Sitgreaves model is inconsistant with past research, and does not make sense intuitively. One possible explanation is that multicolinearity between grass and forbs may have resulted in an inaccurate estimate of the coefficient. The correlation between grass and forbs for the ponderosa pine plots is .70. This high correlation makes it difficult to estimate the effects of either grass or forbs independently of each other. Another possible explanation is that with the small number of plots (37) with which the ponderosa pine model was derived, one or two deviant plots may have influenced the coefficient of forbs. That is, if one or two plots high in forbs were unattractive because of some extraneous factor (e.g., photographic quality or lighting) this could have caused forbs to receive a negative coefficient. Examination of the slides did not, however, reveal any evidence that this had occurred.

The coefficients in the models based on Apache-Sitgreaves plots combined with Coconino plots are in agreement with past research, but the low multiple

R's raise questions about the feasability of a combined model. It may be that the relationship between scenic beauty and physical features is different in the two forests, so that a single model cannot make good predictions for both forests. If this is true, it means that new models may need to be developed for each new area in which the SBE method is to be applied. Another possible explanation is that the estimates of ground cover weights may not be comparable between the two forests. Range estimates were done by different people in the two inventories, and if their approach to the estimation task differed, then combining the two sets of data could create problems. Table 10 shows that there are large differences in the standard deviations for all three classes of ground cover between the two forests.

Table 10. Means and Standard Deviations of Ground Cover variables.

	Apache-Sitgreaves		Coconino	
	Mean	S.D.	Mean	S.D.
Grass	50.7 lbs/acre	38.5	67.3	103.6
Forbs	57.8	54.2	87.9	151.3
Shrubs	10.5	21.8	37.0	100.7

The plots with the most ground cover in the Coconino Inventory had estimated weights approximately three times as great as the plots with the most ground cover in the Apache-Sitgreaves Inventory. Such large differences in ground cover were not, however, evident in the pictures of the plots. This could be explained if, for example, the estimator for the Apache-Sitgreaves consistently underestimated the weight of heavy plots. It is also possible that, due to seasonal differences, the ground cover in the Coconino Inventory may have had a lower moisture content than the Apache-Sitgreaves, and therefore did not appear as lush and green. Since the models use estimates of dry weight,

the effect of moisture content would be left out of the model. If either explanation is true, then standardizing each estimator's range estimates with respect to his own mean and standard deviation might improve the performance of the scenic beauty regression model. This was done by subtracting each estimator's mean estimate from all of his estimates and dividing by the standard deviation of his estimates (i.e., a Z transformation). When the regression analysis was performed with these standardized estimates, the multiple R for ponderosa pine plots improved from .58 to .66, and the multiple R for all plots improved from .66 to .69. This suggests that differences in the range estimation procedures or differences in the moisture content of the ground cover did contribute to the poor performance of the combined model. Additional measurements on the same or other Apache-Sitgreaves plots will be required to resolve the differences in the two forest models and to determine the feasability of a combined model.

Conclusions

Applying established scenic beauty regression modeling methods to the Apache-Sitgreaves National Forest resulted in models for ponderosa pine and mixed species landscapes which perform as well as similar models developed earlier for the Coconino National Forest. Differences between the exact form of the models for the two forests indicate that care should be exercised in attempting to extend models developed in one region to forest areas outside that region. The generally similar character of the models does, however, give hope that extended models covering several regions can ultimately be accomplished.

When extending models from one forest to another, or when combining data from two different areas, it is essential that the data be comparable. The methods used to collect data in the two forests should not introduce any sources of bias. This requires either that different forests use the same

estimation procedures (with care to adjust adequately for differences between individual estimators), or that careful research be performed to ensure that different estimation procedures give comparable results. In some cases it may be desirable to modify standard procedures to obtain data which is more useful for scenic beauty prediction. For example, the usual range estimation procedure produces estimates of dry weight, but moisture content may affect the appearance of ground cover so estimates of wet weight may be more useful for predicting scenic beauty. It would be a simple matter for the range estimator in the field to check the wet weight of clipped plots with a small scale, so that this data would be available.

References

Arthur, L. M. 1977. Predicting scenic beauty of forest environments: some empirical tests. Forest Science 23:151-159.

Brown, J. K. 1974. Handbook for inventorying downed woody material. USDA Forest Service General Technical Report INT-16, Intermountain Station, Ogden, Utah.

Daniel, T. C. and Boster, R. S. 1976. Measuring landscape esthetics: the SBE method. USDA Forest Service Research Paper RM-167, Rocky Mountain Station, Fort Collins, Colorado.

Schroeder, H. W. and Daniel, T. C. Scenic beauty prediction model: Coconino National Forest. USDA Forest Service Final Report 16-743.01-CA, Rocky Mountain Station, Fort Collins, Colorado.